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Assessment of renal function status in occupationally exposed individuals in cable manufacturing factory in Nnewi

AN Okpogba[1], **EC Ogbodo**[2✉], **CG Ikimi**[3], **IC Ejiogu**[1], **UN Agada**[4], **AK Amah**[5], **UC Edward**[6], **DE Nwanguma**[7], **JC Nnamdi**[8], **EC Onyeneke**[9]

[1,5]Department of Human Biochemistry, Faculty of Basic Medical Sciences, Nnamdi Azikiwe University, Nnewi Campus, Anambra State, Nigeria; [2]Department of Medical Laboratory Science, Faculty of Health Sciences and Technology, Nnamdi Azikiwe University, Nnewi Campus, Anambra State, Nigeria; [3]Department of Biochemistry, Federal University of Otuoke, Bayelsa State, Nigeria; [4]Histopathology unit, Department of Medical Laboratory Services, Alex Ekwueme Federal University Teaching Hospital, Abakaliki, Ebonyi State, Nigeria; [5]Department of Human Physiology, College of Medicine, Imo State University, Owerri, Nigeria; [6]Department of Chemical Pathology, College of Medicine, Imo State University, Owerri, Nigeria; [7]Department of Medical Laboratory Science, Imo State University, Owerri, Nigeria; [8]Department of Chemical Pathology, Faculty of Medicine, Nnamdi Azikiwe University, Awka, Nigeria; [9]Department of Biochemistry, University of Benin, Benin City, Edo State, Nigeria.

✉**Corresponding Author:**
Email: augustinee442@gmail.com; +2348134488042

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General Note
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ABSTRACT

Background of study: The effect of effluents from a factory environment on the workers may pose a potential risk for workers' health. *Aim:* This is a cross sectional study designed to assess the renal function status in occupationally exposed individuals in cable manufacturing factory in Nnewi, Nigeria. *Methods*: A total of 39 cable manufacturing factory workers who were aged between nineteen and fifty-six years and 79 control subjects (comprising of 39 control subjects from Nnewi (N) and 40 control subjects from Elele (E) respectively) aged between 18 and 44 years were recruited for the study. Venous blood sample was collected from each subject and renal indices involving plasma creatinine, urea and electrolytes levels determined. *Results*: Results showed that the cable manufacturing factory workers had a significantly elevated potassium and sodium levels, significantly decreased bicarbonate and urea concentrations respectively ($p<0.05$), whereas both plasma creatinine and chloride concentrations did not differ significantly in the factory workers when compared with control subjects respectively ($p>0.05$). *Conclusion*: Therefore, this study has shown no negative effect on the kidney function status of cable manufacturing factory workers in Nnewi.

Keywords: age, Body mass index (BMI), cable manufacturing factory workers, kidney, kidney function, Length of service (LOS).

1. INTRODUCTION

The manufacturing process of industrial conductors involves many stages, such as drawing, stranding, compacting, extrusion, and assembly [1]. Those processes consist of assembling concentric layers twisted helically around a central core [2]. The production of the conductive core involves cold deformation processes such as stranding and compaction. During the stranding process, several physical phenomena may be observed: the wires are subjected to pooling and twisting forces, compression (with the compacting die), and tangential forces generated as a result of friction between the wires [3] all of these affect the metallurgical state of the material and overall mechanical and electrical performance of the conductor [4]. The materials necessary for cable manufacturing include; resins, plasticizers, stabilizers, fillers, flame retardants, lubricants and colourants. Metals such as zinc, lead and copper besides being used in forming an aspect of the core of the cable also are utilized as colourants to aid in identification. Pigments are typically identified by their colour families and to some extent their properties. Common inorganic types of pigments include; Lead, cadmium, lead chromate, titanium dioxide, zinc sulfide, iron oxides, cadmium oxides, ultramarines, mixed metal oxides, and carbon black [5].

The kidneys remove waste products from the body and have the primary role of maintaining homeostasis which may be negatively affected by exposure to toxins such as heavy metals found in the workplace among factory workers. Exposure to heavy metals is higher in the workplace than in the external environment [6]. Okpogba et al. had earlier recorded an elevated levels of these heavy metals in the present study area [7, 8]. Several authorities had earlier documented varying reports in this respect [9, 10, 11]. Therefore, the present study focuses on the assessment of the renal function status in occupationally exposed individuals in cable manufacturing factory in Nnewi, Nigeria.

2. MATERIALS AND METHODS

Study design

This work assessed the renal function parameters in the blood of cable manufacturing factory workers in Nnewi, Anambra State South eastern Nigeria.

A total of thirty-nine (39) apparently healthy individuals in the exposed group (Cable manufacturing factory workers) aged between 19 and 56 years were recruited for the study. The exposed group comprised workers from cable manufacturing factory who were constantly being exposed to effluents from the factory. None factory workers comprising of thirty-nine (39) staff and undergraduate students of the College of Health Sciences, Nnamdi Azikiwe University, Nnewi Campus whose residential homes were at least 5-10 km from the factory sites and forty (40) staff and undergraduate students of the Faculty of Medicine, Madonna University, Elele were recruited as control in this work. This control individuals were aged between 18 and 44 years. Informed consent was obtained from all individuals after being educated on the benefit of the study and completing of a structured questionnaire. Thereafter, 5ml of venous blood sample was collected from each individual for the evaluation of biochemical parameters.

Estimation of Serum Creatinine Level

Serum creatinine level was assayed using Jaffe-Slot Alkaline Picric Acid Method as described by Ochei and Kolhatkar [12].

Estimation of Serum Urea

Estimation of serum urea level was done using Berthlot Method as described by Ochei and Kolhatkar [12].

Electrolytes Profile Assay

Assay for sodium, potassium, chloride and bicarbonate concentrations were done by the method according to Kulpmann [13].

Inclusion criteria

Apparently healthy individuals aged between 19 and 56 years who were exposed to cable manufacturing factory sites and non factory workers were assembled for this study.

Exclusion criteria

Factory workers whom are known to have health issues ranging from kidney disease, alcoholics or smokers and also factory workers who did not meet up the age required were rule out from the study.

Ethical consideration

Ethical approval for this study was sought and obtained from Ethical Committee, Nnamdi Azikiwe University Teaching Hospital, Nnewi, Anambra State, Nigeria (NAUTH/CS/66/Vol.2/149).

Statistical analysis

The data were presented as mean±SEM and the mean values of the control and test group were compared by Students t-test and Pearson's bivariate correlation coefficient using Statistical package for social sciences (SPSS) (Version 16) software. Statistical significance was pecked at a P-value less than 0.05 ($P<0.05$).

3. RESULTS

The kidney function status of the control subjects (N and E) and factory workers are presented in Table 1. Control N subjects had a significantly higher urea level than those of control E (2.17±0.04; $p<0.05$) while the creatinine level of control N subjects (75.59±1.48) was higher than control E though non- significantly ($p>0.05$). The urea/creatinine ratio (U/C ratio) of control N subjects 70.70±32.57±0.86) was significantly elevated ($p<0.05$) compared to control E subjects (32.57±0.86). Figures 1 and 2 present the regression analyses of the kidney parameters of control N and control E subjects with BMI. In control N, while K^+, Cl^- and HCO_3^- were positively correlated with BMI, Na^+, urea, creatinine and U/C ratio were negatively correlated. In control E, except for creatinine which correlated positively with BMI, urea and U/C ratio were negatively correlated, though non-significantly ($p>0.05$) in either control N or E subjects.

Table 1: Kidney function status of cable manufacturing factory workers

Factory	Na^+ ion (mmol/L)	K^+ ion (mmol/L)	Cl^- ion (mmol/L)	HCO_3^- ion (mmol/L)	Urea (mmol/L)	Creatinine (µmol/L)	U/C ratio
N (n=39)	122.87 ± 0.78^a	3.28 ± 0.04^a	99.25 ± 0.18^b	26.73 ± 0.20^b	5.32 ± 0.09^c	75.59 ± 1.48^{bc}	70.70 ± 0.66^b
E (n=40)	N/A	N/A	N/A	N/A	2.17 ± 0.04^a	67.71 ± 1.23^{ab}	32.57 ± 0.86^a
X (n=39)	142.87 ± 0.76^d	4.23 ± 0.07^b	101.62 ± 0.72^b	21.95 ± 0.36^a	3.33 ± 0.25^b	84.77 ± 3.88^{cd}	43.69 ± 4.41^a

Values are in mean (±SEM); within the column, mean with different superscripts are statistically significant ($p<0.05$).

KEY:

N: Control subjects from Nnewi
E: Control subjects from Elele
X: Workers from cable manufacturing factory
U/C ratio: Urea/Creatinine ratio
N/A: Not Analyzed

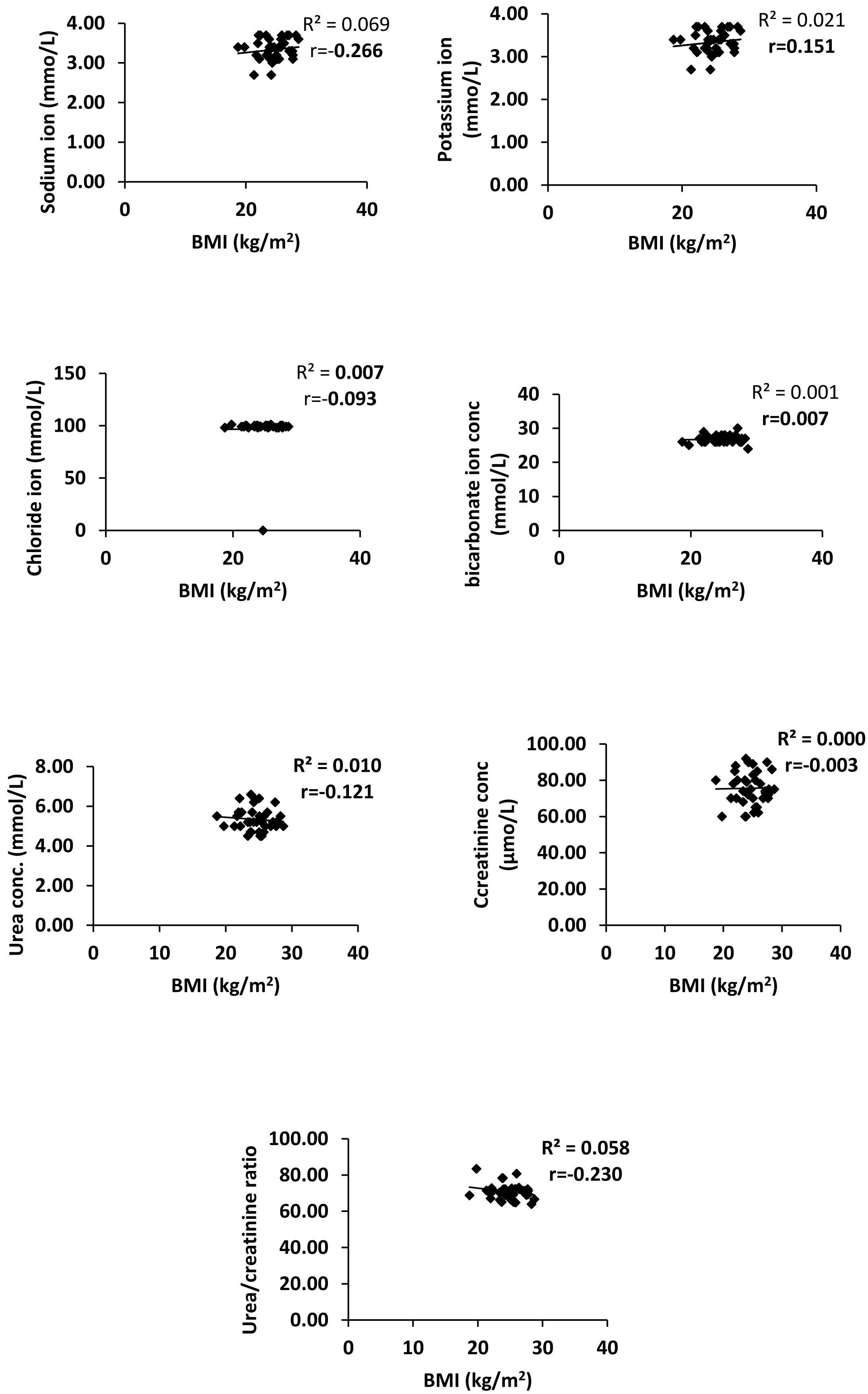

Figure 1: Regression of kidney function analytes of control subjects with BMI (Nnewi).

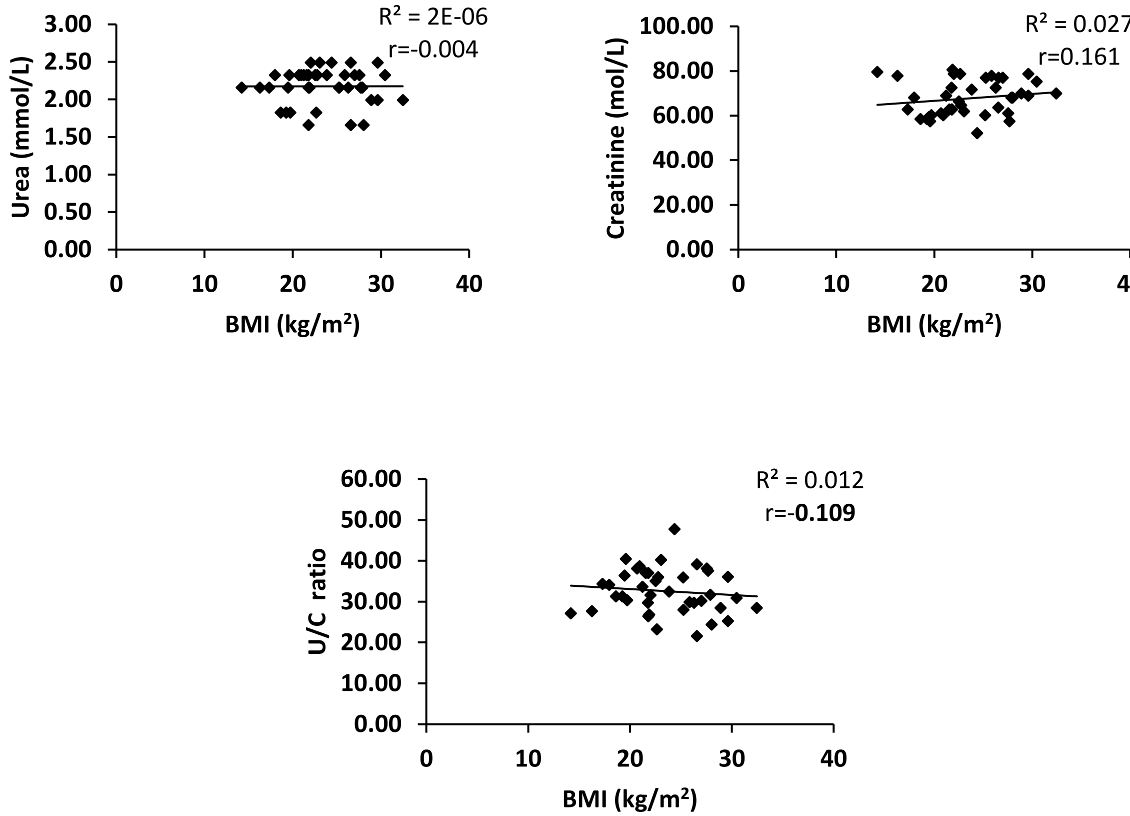

Figure 2: Regression of kidney function status of control subjects with BMI (Elele)

The sodium ion (Na^+) and potassium ion (K^+) levels of cable manufacturing (Na^+=142.87±0.76 Vs 122.87±0.78; K^+=4.23±0.07 Vs 3.28±0.04), factory workers were significantly elevated ($p<0.05$) compared to that of control N subjects (122.87±0.78), but Cl^- level of cable manufacturing factory workers were not changed. However, the bicarbonate ion (HCO_3^-) concentrations in the factory workers (21.95±0.36), were significantly reduced ($p<0.05$) than in control.

Urea concentration of cable manufacturing (3.33±0.25) factory workers was significantly reduced ($p<0.05$) than in control N subjects, however, it was significantly elevated ($p<0.05$) compared with control E (2.17±0.04) subjects. Creatinine concentration was elevated although non-significantly ($p>0.05$) in the factory workers compared with control N (75.591.48) subjects. The U/C ratio was significantly reduced ($p<0.05$) in cable manufacturing (43.69±4.41) factory workers when compared with control N (70.70±0.66) subjects.

Table 2: Effect of age on the kidney function status of cable manufacturing factory workers

Age group	Na^+ (mmol/L)	K^+ (mmol/L)	Cl^- (mmol/L)	HCO_3^- (mmol/L)	Urea (mmol/L)	Creatinine (μmol/L)	U/C ratio
N (n=39)	122.87±0.78^a	3.28±0.04^a	99.25±0.18^a	26.73±0.20^d	5.32±0.09^b	75.59±1.48^a	70.70±0.66^b
18-30yrs (n=21)	143.36±0.99^{ab}	4.23±0.10^b	101.40±1.00^a	21.36±0.43^{ab}	3.35±0.36^a	85.99±5.11^a	40.76±4.74^a
31-40yrs (n=12)	142.00±1.43^{ab}	4.26±0.13^b	101.55±1.53^a	22.91±0.73^{ab}	3.29±0.43^a	81.97±8.69^a	51.10±12.09^{ab}
41-50yrs (n=4)	140.50±2.90^b	4.05±0.16^b	102.25±2.01^a	21.00±0.71^a	3.04±0.74^a	86.19±8.37^a	35.36±7.39^a
51-60yrs (n=2)	147.00±1.00^{ab}	4.45±0.15^b	103.00±3.00^a	25.00±0.00^{cd}	4.00±0.22^{ab}	83.98±22.10^a	51.91±16.23^{ab}

Values in mean (±SEM); within column, means with different superscripts are statistically significant ($p<0.05$)

KEY:

N: Control subjects

U/C Ratio: Urea/Creatinine ratio

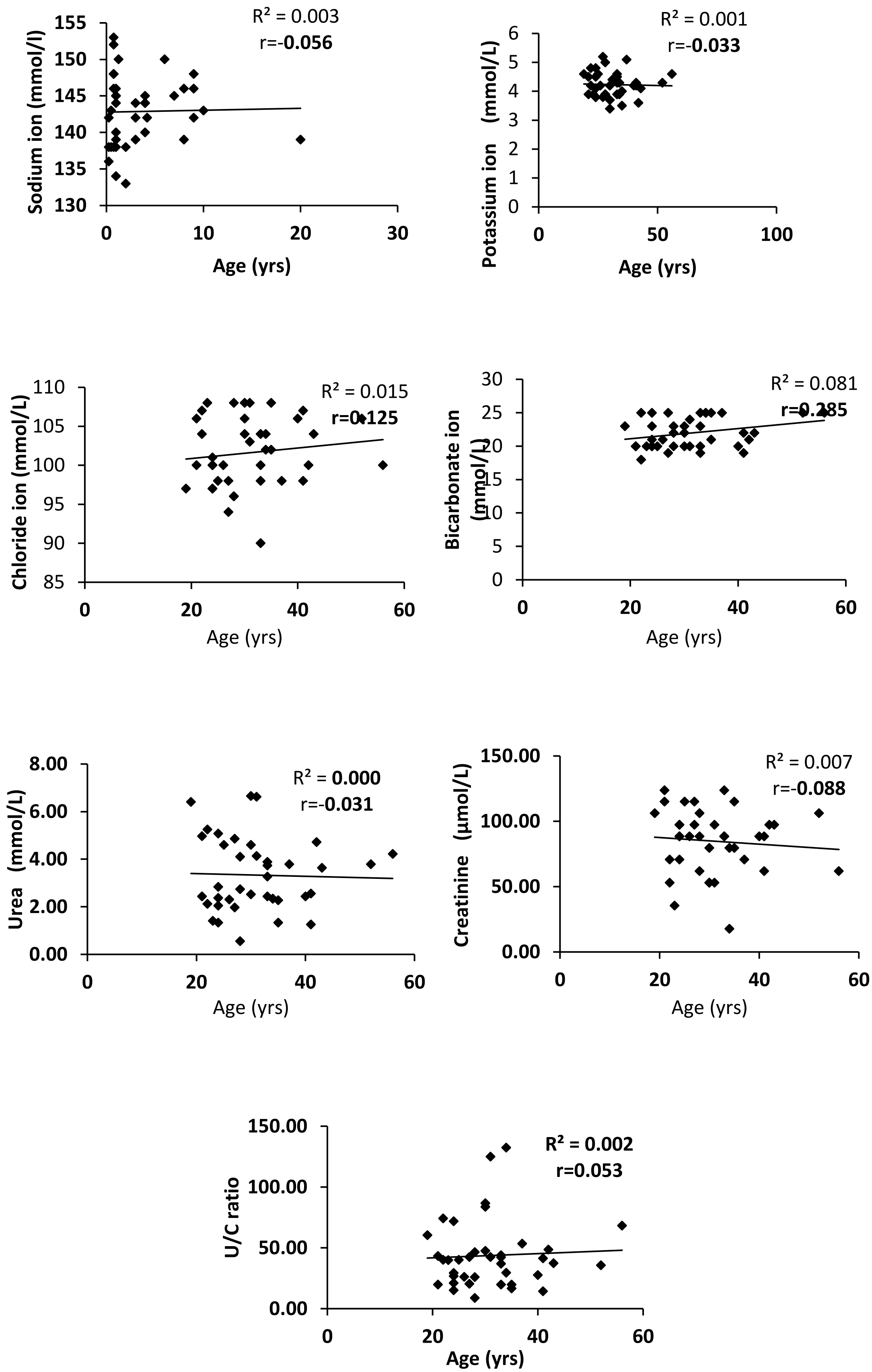

Figure 3: Regression of kidney function status of cable manufacturing factory workers with age

The effects of age and LOS on the kidney function parameters of cable manufacturing factory workers are presented in Tables 2 and 3, respectively while Figures 3 and 4 present the regression analyses with age and LOS, respectively. Sodium ion (Na^+) of factory workers were significantly elevated (P<0.05) in the 41-50 and 51-60yrs age group while K^+ was similarly elevated in all the age groups compared to their different controls. HCO_3^- and urea concentrations were significantly reduced (p<0.05) in all the age groups up to the 41-50yrs age group. While Na^+, K^+, urea and creatinine correlated negatively with age, Cl^-, HCO_3^-, and U/C ratio correlated positively with age, though non-significantly (p>0.05) in each case.

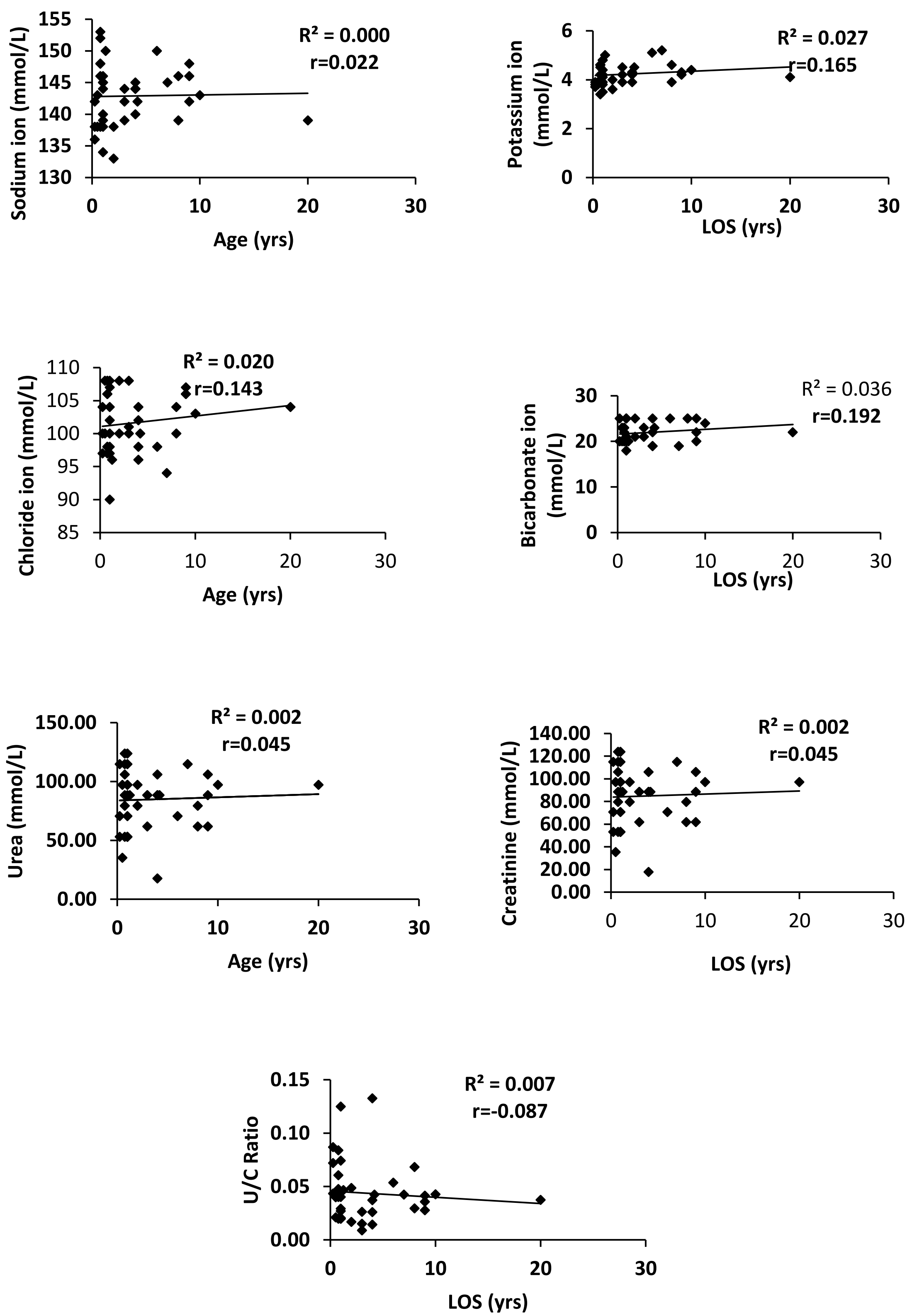

Figure 4: Regression of kidney function status of cable manufacturing factory workers with LOS

Table 3: Effect of LOS on the kidney function status of cable manufacturing factory workers

LOS group	Na^+ (mmol/L)	K^+ (mmol/)	Cl^- (mmol/L)	HCO_3^- (mmol/L)	Urea (mmol/L)	Creatinine (μmol/L)	U/C ratio
N (n=39)	122.87±0.78^a	3.28±0.04^a	99.25±0.18^a	26.77±0.20^c	5.32±0.09^b	75.59±1.48^a	70.70±0.66^b
0-5yrs (n=30)	142.47±0.91^b	4.16±0.07^b	101.37±0.84^{ab}	21.63±0.39^a	3.27±0.31^a	84.27±4.71^a	44.20±5.62^{ab}
6-10yrs (n=5)	145.00±1.92^b	4.58±0.24^b	101.60±2.40^{ab}	22.80±1.35^{ab}	3.44±0.47^{ab}	91.94±8.20^a	37.71±4.72^a
11-15yrs (n=2)	144.00±2.00^b	4.25±0.50^b	101.50±1.50^{ab}	24.50±0.05^{bc}	4.17±0.05^{ab}	79.50±17.68^a	55.33±12.82^{ab}
16-20yrs (n=2)	142.50±3.50^b	4.35±0.25^b	105.50±1.50^b	22.00±1.50^{ab}	3.10±0.54^a	75.56±17.66^a	39.35±1.96^a

Values are in mean (±SEM); within column, mean with different superscript s are statistically significant ($p<0.05$)

Key:

N: Control subjects

LOS: Length of service

U/C ratio: Urea/ creatinine ratio

The effect of LOS showed that Na^+ and K^+ were significantly elevated ($p<0.05$) while Cl^- was only elevated significantly at the 16-20yrs LOS group. HCO_3^- and urea levels were reduced significantly ($p<0.05$) in the 0-5 and 6-10yrs LOS groups, respectively, compared to the control subjects while creatinine showed no significant difference between the LOS groups and the control. Except for U/C ratio which negatively correlated with LOS, Na^+, K^+, Cl^-, HCO_3^-, urea and creatinine correlated positively with LOS, though non-significantly ($p>0.05$).

4. DISCUSSION

In this study, the urea and creatinine levels of Nnewi control subjects were higher than those of Elele control subjects. Urea is the major metabolic waste product of protein metabolism. Increased urea and creatinine levels indicate a compromised kidney status and this was evidenced by the statistically different ($p<0.05$) urea/creatinine ratio. Although those values were higher in the Nnewi control than the Elele control, they were within the normal ranges; however, if the progression continues, the kidneys of Nnewi control subjects may show earlier signs of renal dysfunction than their Elele counterparts.

The effect of effluents from a factory environment on the workers may pose a potential risk for workers' health. Interactions between these effluents and living tissues may cause disturbances of pro- and anti-oxidant balance of the body. The results of the present study showed that exposure of some factory workers in the cable manufacturing factory in Nnewi significantly increased ($p<0.05$) the values of sodium and potassium ions in the sera of the factory workers. On the other hand, the bicarbonate ion levels were significantly decreased in the cable manufacturing factory workers when compared with the control. In all cases, the values were within the acceptable normal range. This report agrees with that of Onuegbu *et al.* on the renal indices of people occupationally exposed to lead [10]. It, however, disagrees with the work of Babalola and Babajide [9], although they reported a significant increase in lead in a group of industrial workers in Ewekoro, Abeokuta granite industry, there was no difference in the sodium and potassium ions of the workers. The elevated sodium ion concentration observed in the serum of the factory workers obtained in this study may have arisen from water loss which is due to inappropriate regulation of osmolarity occasionally due to renal or hepatic disease or prolonged sweating without access to water. As for increased potassium ions observed in the cable manufacturing factory workers, it may have been due to the inability of the kidneys to excrete ingested potassium probably due to dehydration [14]. Maintenance of the proper potassium ion concentration of the extracellular fluids is essential particularly for the proper functioning of the heart. High concentrations cause widespread intra-cardiac block while low concentrations impair the contractility of the heart muscle.

The assessment of the plasma urea and creatinine concentrations is used to establish the presence or otherwise of renal insufficiency [15] and they are the major catabolic products of protein and muscle metabolism, respectively. Higher than normal levels of urea and creatinine are indications of renal dysfunction [16]. In this study, the urea concentrations obtained was decreased significantly in cable manufacturing factory workers while the creatinine concentration was elevated although non-significantly in the cable manufacturing factory workers when compared with the control. This report is in consonance with Zinat *et al.* who reported significantly reduced urea and creatinine levels in lead-exposed Bangladesh automobile workers [11]. However, the present finding is in contrast with the earlier work of Okpogba *et al.* which documented decreased bicarbonate level with no significant differences observed in the mean levels of potassium, sodium, chloride, urea and cretinine in the factory chickens in Nnewi [17]. The

observed decrease in urea concentration in the cable manufacturing factory workers may be due to the fact that these workers consume protein-deficient diet as urea production is a fall out of protein metabolism which increases with high protein intake.

5. CONCLUSION

This study revealed significantly elevated levels of potassium and sodium and a decrease in bicarbonate ion level and urea concentration than in the cable manufacturing factory workers. However, both chloride level and creatinine concentration were similar compared with control subject. It follows therefore that the kidney function status in these occupationally exposed workers in cable manufacturing factory are not compromised.

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This study has not received any external funding.

Conflict of Interest:
The authors declare that there are no conflicts of interests.

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External peer-review was done through double-blind method.

Data and materials availability:
All data associated with this study are present in the paper.

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